

**INtelligent, Fast, Interconnected and Efficient devices, for frontier exploitation in Research and Industry**

Funding Scheme: FP7-PEOPLE-2012-ITN

Grant Agreement number: 317446

Project acronym: INFIERI



**DELIVERABLE NAME: APPLICATION OF OPTICAL WIRELESS COMMUNICATION TO MEDICAL IMAGING**

**DELIVERABLE REF. N°: 3.5**

**WORK PACKAGE: WP3**

**NATURE OF THE DELIVERABLE:** R= Report, P = Prototype, D = Demonstrator, O = Other

**BENEFICIARY(IES) CONTRIBUTOR(S): SSSA**

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**DELIVERY DATE FROM ANNEX 1: 48**

**DISSEMINATION LEVEL:** RE, CO

PU = Public N/A IN THE INFIERI CONTEXT

PP = Restricted to other programme participants (including the Commission Services) N/A IN THE INFIERI CONTEXT

RE = Restricted to a group specified by the consortium (including the Commission Services) **HIGHLY SUGGESTED IN THE INFIERI CONTEXT**

CO = Confidential, only for members of the consortium (including the Commission Services) **HIGHLY SUGGESTED IN THE INFIERI CONTEXT**

**Abstract:**

A novel Optical Wireless Communication (OWC) system has been designed and tested to minimize the electronic signal processing within a Positron Emission Tomography (PET) insert to make it compatible with a Magnetic Resonance Imaging (MRI) system. The analogue signals from the PET-MRI were transmitted through the OWC link, performing all the post processing in the base station, positioned at 1.5 m away from the huge magnetic field of the MRI.

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Period covered: from 01/02/2013 to 31/01/2017

Project website: <http://infieri-network.eu>

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We successfully exploited a 680nm Vertical Cavity Surface Emitting Laser (VCSEL) as optical transmitter (Tx) and an Avalanche photodiode as receiver (Rx). Suitable optical lenses at Tx and Rx sides were used to achieve 1.5 m transmission distance.

In order to analyze the OWC performance, we compared the received signals with the original signals from the PET-MRI. The results, reported in the insets of Figure 1, are promising and show that the OWC is a viable solution to avoid Electro-Magnetic Interference (EMI) in the PET-MRI system, because the main characteristics of the transmitted pulses were preserved after the transmission.

To reduce further the number of OWC links for each detector, we also performed a preliminary study of analogue Time Division Multiplexing (aTDM) technique. We transmitted the four channels of a detector through a single OWC link, where each channel is in delayed respect to the others (Field flood diagram in Fig 1c). The complete idea was filed as a patent ([7], in “publications” list) and then submitted for publication.

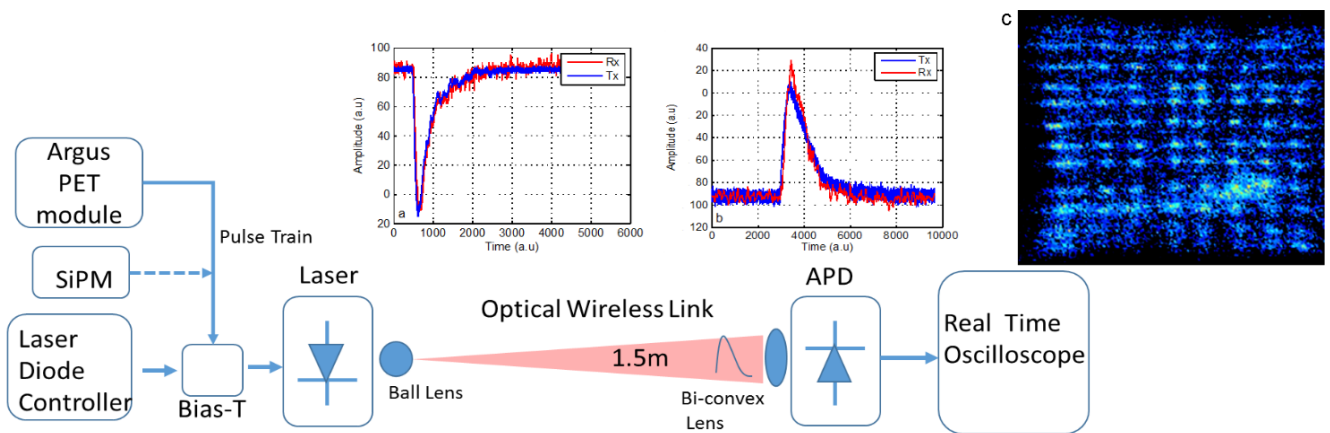


Figure 1: Experimental setup of OWC analogue signal transmission at 1.5 m distance; APD : avalanche photodiode, SiPM: silicon photomultiplier; insets a&b shows the comparison between the transmitted (Tx, in blue) and Received (Rx, in red) waveform (pulses) for the Argus PET module and the SiPM respectively; c: Field flood diagram using aTDM received signal through OWC link.

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## Talks

- [1] Presentation on "Optical Wireless for data transmission" 1<sup>st</sup> INFIERI Summer school Oxford July 2013
- [2] PhD introductory presentation, 3rd INFIERI Workshop Madrid January 20-22 2014.  
<https://indico.cern.ch/event/281636/contribution/3/8/material/slides/1.pdf>
- [3] Presentation on "Optical wireless multi-gigabit data transfer for CMS silicon tracker" 3rd INFIERI Workshop Madrid January 20-22 2014.
- [4] Presentation on "Feasibility of Optical Wireless transmission systems for CTA" 3rd INFIERI Workshop Madrid January 20-22 2014.
- [5] PhD progress report presentation for midterm review, 4th INFIERI Workshop Amsterdam December 2014.
- [6] Presentation on "Lab Test For OWC at SSSA and CERN Secondment prospects" 5th INFIERI Workshop Geneva April 27-29 2014
- [7] Presentation on "Recent Progress in Optical Wireless Communication" 5th INFIERI Workshop Geneva April 27-29 2014
- [8] Presentation on "SSSA ESR WP3 progress report and perspectives" 6<sup>th</sup> INFIERI Workshop Pisa October 27<sup>th</sup>-29<sup>th</sup> 2015.
- [9] Presentation on "SSSA ESR WP3 progress report" 7th INFIERI Workshop Lisbon April 12th-15th 2016.

## Poster Presentations

- [1] W.Ali., "High Speed Data Transmission and Processing" , at the 2nd International Summer School on "Intelligent Signal Processing for Frontier Research and Industry, INFIERI2014, Paris, July 14-25, 2014;  
<https://indico.cern.ch/event/305730/session/28/contribution/74/material/slides/0.pdf>
- [2] W.Ali, "High Speed Data Transmission and Processing", at 4th "Intelligent Signal Processing for Frontier Research and Industry" (INFIERI) Workshop Amsterdam (The Netherlands) December 10-12, 2014.  
<http://infieri-network.eu/sites/default/files/PosterWajahatAli.pdf>
- [3] W. Ali et al, " Optical Wireless Communication System for Particle Detectors in High Energy Physics" 13<sup>th</sup> Pisa Meeting Isola d'Elba May 24<sup>th</sup>-30<sup>th</sup> 2015.
- [4] W.Ali et al, "2.5 Gb/s Optical Wireless Communication Systems for Particle detectors in High Energy Physics", 3<sup>rd</sup> International Summer School on "Intelligent Signal Processing for Frontier Research and Industry, INFIERI 2015, Hamburg, September 14-25, 2015;
- [5] W.Ali et al, "2.5 Gb/s Simple Optical Wireless Communication Systems for Particle detectors in High Energy Physics", The 25th International workshop on Vertex Detectors 25-30 September 2016 La Biodola, Isola d'Elba, Italy.

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**Publications:**

- [1] Giulio Cossu, Ali Wajahat, Raffaele Corsini, Ernesto Ciaramella, "5.6 Gbit/s Downlink and 1.5 Gbit/s Uplink Optical Wireless Transmission at Indoor Distances ( $\geq 1.5$  m)" Optical Communication (ECOC, 2014), 40th European Conference and Exhibition on Sept. 2014.
- [2] W. Ali et al., "High Speed Optical Wireless Data Transmission System for Particle Sensors in High Energy Physics", 2015 JINST 10 C08003.
- [3] W. Ali, R. Corsini, E. Ciaramella, R. Dell'Orso, A. Messineo, F. Palla, "Optical Wireless Communication system for particle detectors in high energy physics", Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 824, 11 July 2016, Pages 245-247
- [4] Giulio Cossu, Wajahat Ali, Raffaele Corsini, and Ernesto Ciaramella, "Gigabit-class optical wireless communication system at indoor distances (1.5 – 4 m)," Opt. Express 23, 15700-15705 (2015)
- [5] W.Ali, et al, "2.5 Gb/s Simple Optical Wireless Communication System for Particle Detectors in High Energy", abstract accepted to be published in Proceedings of Science)
- [6] G. Konstantinou, W.Ali, et al., "Experimental demonstration of an optical wireless MRI compatible PET/SPECT insert front-end", to be published in NSS/MIC IEEE proceedings
- [7] Wajahat Ali, et al., "Sistema de deteccin de radiacin gamma y sistema de resonancia magntica",  
Spanish patent ID: P201631388 (filed in October 2016)

**Secondments of W. Ali at UC3M and of G. Konstantinou at SSSA-Pisa**

**PhD:** This work is included in the PhD of the two EU Fellows; W. Ali defended at SSSA, On Dec 1<sup>st</sup> 2016, G. Konstantinou to be defended at UC3M, on May 2017.